Implications of MOVES Model for Transportation Communities

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by

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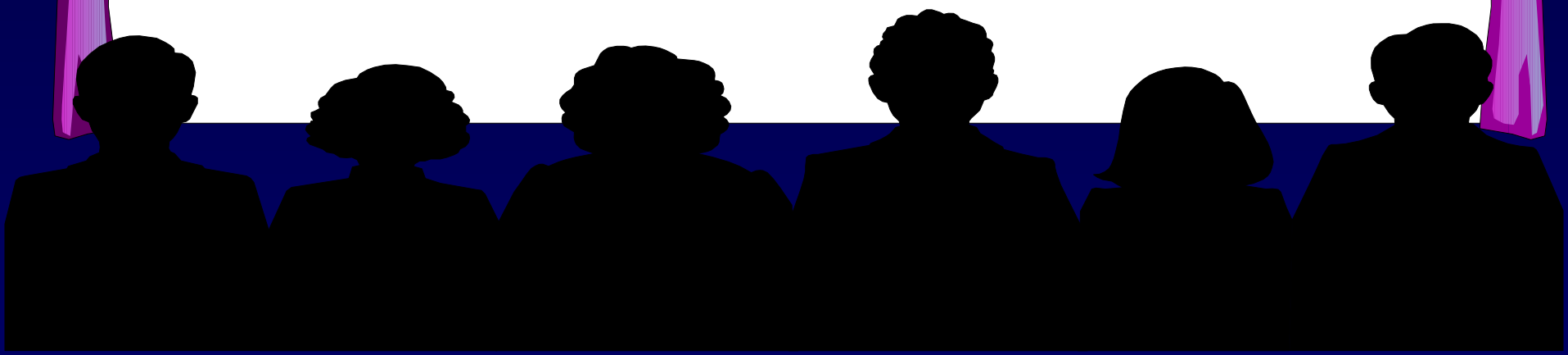
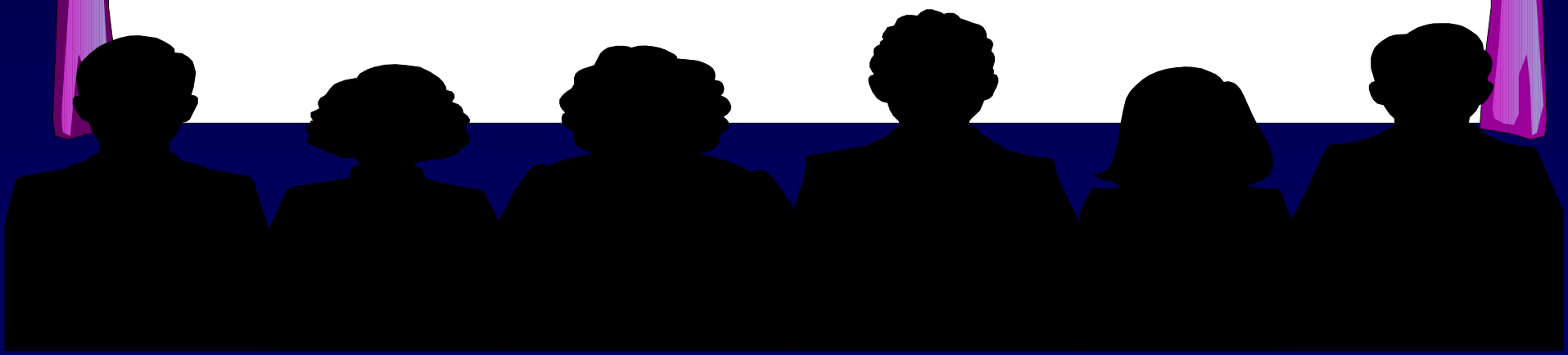
1. System/Software



Written In

- Java™
- MySQL
  - Relational database management system
- Works in
  - Windows 2000, NT and XP

2. Basic Emission Rates

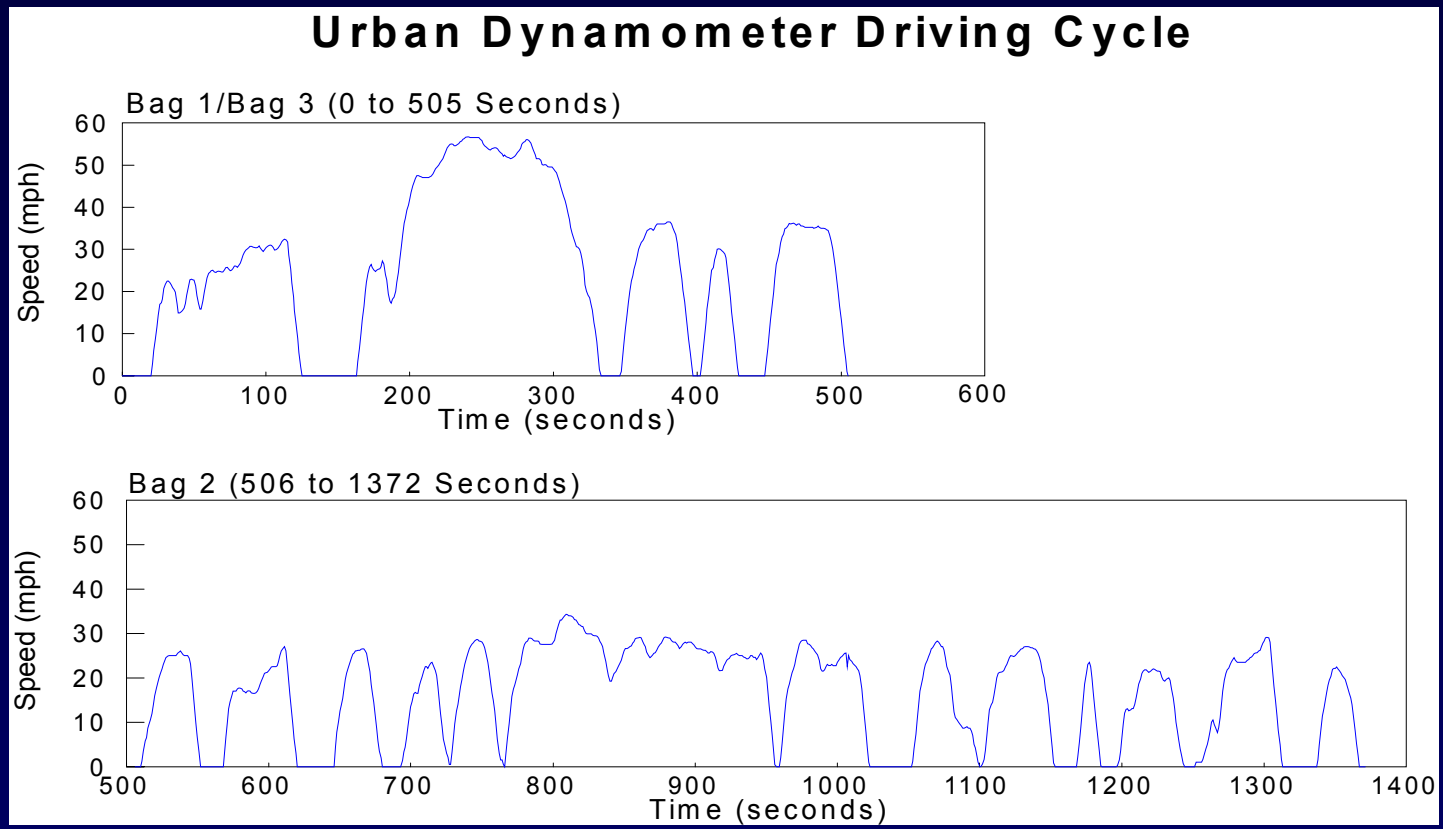


Basic Emission Rates MOBILE1-5

- Trip based drive cycles
  - Running & start emissions
  - No separation of facilities
- Bag 1, Bag 2, & Bag 3
- Start Emissions (Bag 1 & Bag 3)
- Evaporation: HC only
  - Hot Soak, Diurnal, Running Losses, Refueling Losses, Crankcase Emissions

Vehicle Drive Cycle

Federal Test Procedure Cycle (LA4 Cycle)



MOBILE1-5 Modeling Approaches

Bag 1: 3.59 mile, Cold Start EM
Bag 2: 3.91 mile, Stabilized Mode EM
Bag 3: 3.59 mile, Hot Start EM
43% of Engine Starts are Cold (3/7)

$$BER = (3.59\ (0.43 \times EM1 + 0.57 \times EM3) + 3.91\ (EM2)) / 7.5$$

$$BER = 0.206\ EM1 + 0.273\ EM3 + 0.521\ (EM2)$$

MOBILE1-5 Modeling Approaches

- Trip based fixed drive cycles
  - No separation of facilities
  - One in one match of drive cycles vs. speeds
  - Application of trip level EF to link level
- Start Emissions (Bag 1 & Bag 3)
  - Added to running emissions (VMT)
  - Collecting operational mode fractions data
  - Allocating the start EM to geo-grid system
- Micro-scale project level AQ analyses
  - Intersection hot spot analyses
  - ITS project evaluation
  - Transient (operational) mode fractions

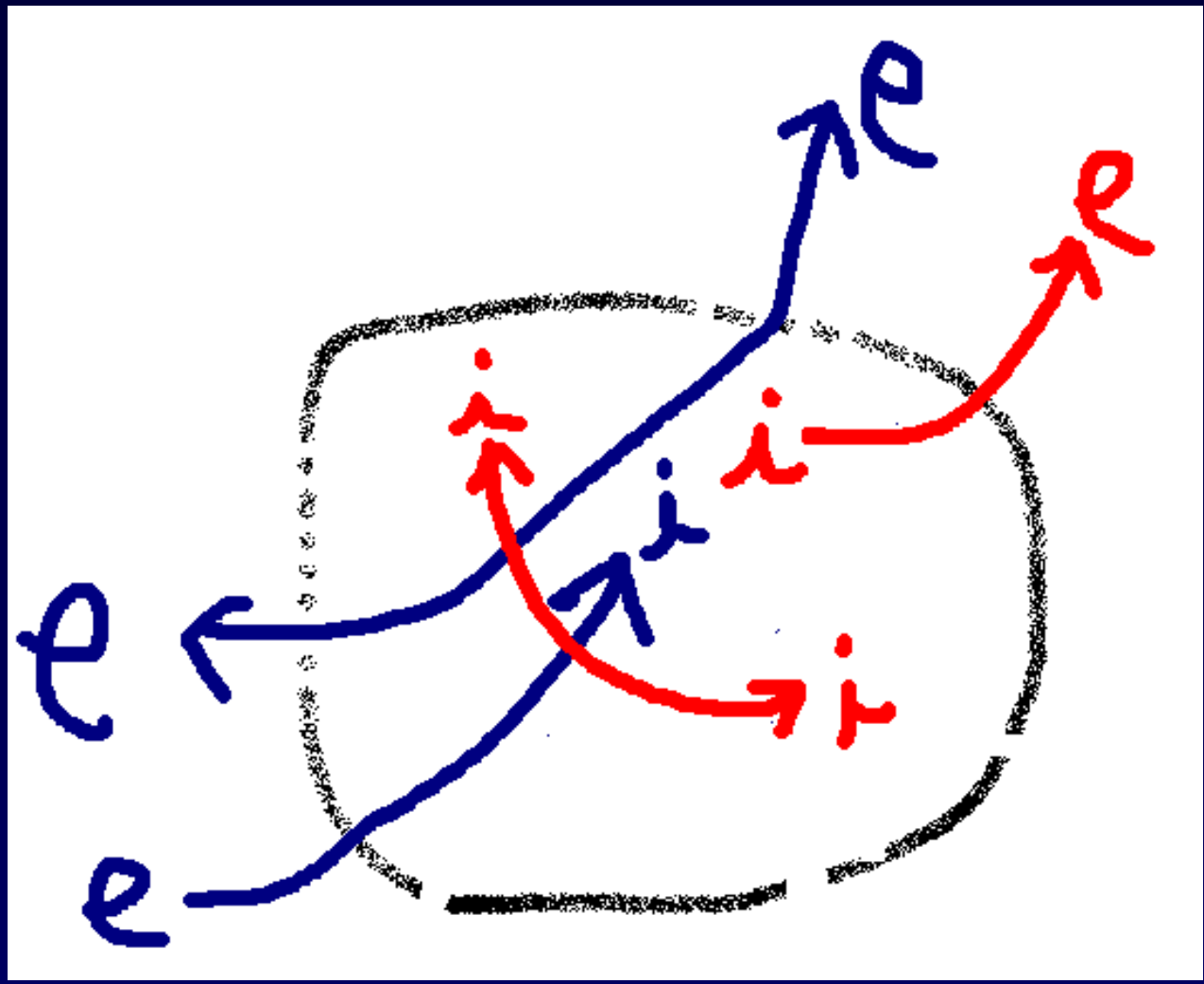
Basic Emission Rates MOBILE6

- Facility based drive cycles
  - Freeway, Arterial, Freeway Ramp, & Local
  - 14 speed bins
- Bag 1, Bag 2, Bag 3, & Running 505
- Optional Start Emissions (Bag 1 & Bag 3 – Running 505)
- Model default # of Starts
- Evaporation: HC only
  - Hot Soak, Diurnal, Running Losses, Refueling Losses, Crankcase Emissions

MOBILE6 Modeling Approaches

- Facility based fixed drive cycles
  - One in one match of drive cycles vs. speeds
  - single speed for Fwy-Ramp & Local Street
  - Application of facility level EF to link level
- Optional separation of start emissions
  - Emissions are sensitive to engine starts
  - Powerful tool for small urban areas with large E-E/E-I travel
- Micro-scale project level AQ analyses
  - Allocating start emissions
  - Intersection hot spot analyses
  - ITS project evaluation

Regional VMT



MOVES Emission Processes

- Running
- Start
- Extended Idle
- Evaporative Processes
  - Permeation, Tank Vapor Venting, Liquid Leaks, Non-Fuel Evaporation, Refueling
- Crankcase
- Tire Wear
- Brake Wear
- Life Cycle Processes

MOVES Modeling Approaches Running Emissions

- **Facility based drive cycles**
  - Urban Freeway, Urban Non-freeway, Rural Freeway, Rural Non-freeway, & Off-network
  - High speed drive cycle
- **VSP based emission factors**
  - Models needed to generate VSP information
    - NEPA project level analysis
    - AQ dispersion modeling
- **Giant step forward in emissions modeling**

VSP vs. Speed

MOVES2006 VSP / Speed Bins

VSP	Speed Class		
	1-25	*25-50*	*50 +*
30 +	16	30	40
27-30			
24-27		29	39
21-24		28	38
18-21			
15-18			37
12-15		27	
9-12	15	25	
6-9	14	24	35
3-6	13	23	
0-3	12	22	33
< 0	11	21	

VSP Class

Generating VSP Information from Traffic Operations Information

$$VSP = v[1.1a + 9.81(\sin(\text{atan}(grade))) + 0.132] + 0.000302v^3$$

where v : vehicle speed (m/s); a: acceleration (m/s^2); $grade$: road grade(%).

Source: Dr. Frey of NC State University

MOVES Modeling Approaches
Start Emissions

- Start rates = "incremental emissions per start"
  - Number of starts by time and place; mesoscale and microscale provide finer resolution of this
  - Separation of engine starts from VMT
  - Allocating start emissions on a project level analysis
- Default number of engine starts (?)
  - Engine starts per VMT (E-E VMT problems)
  - Engine starts per vehicle
  - Engine starts per vehicle trips (inter zonal & intra zonal)
- Soak time bins defined as operating modes
  - Soak distribution calculated within model from instrumented vehicle data

MOVES Modeling Approaches Evaporative Emissions HC Only

- MOBILE1-6
  - Hot Soak, Diurnal, Running Losses, Refueling Losses, Crankcase Emissions
- MOVES
  - Permeation, Tank Vapor Venting, Liquid Leaks, Refueling, Non-fuel evaporation

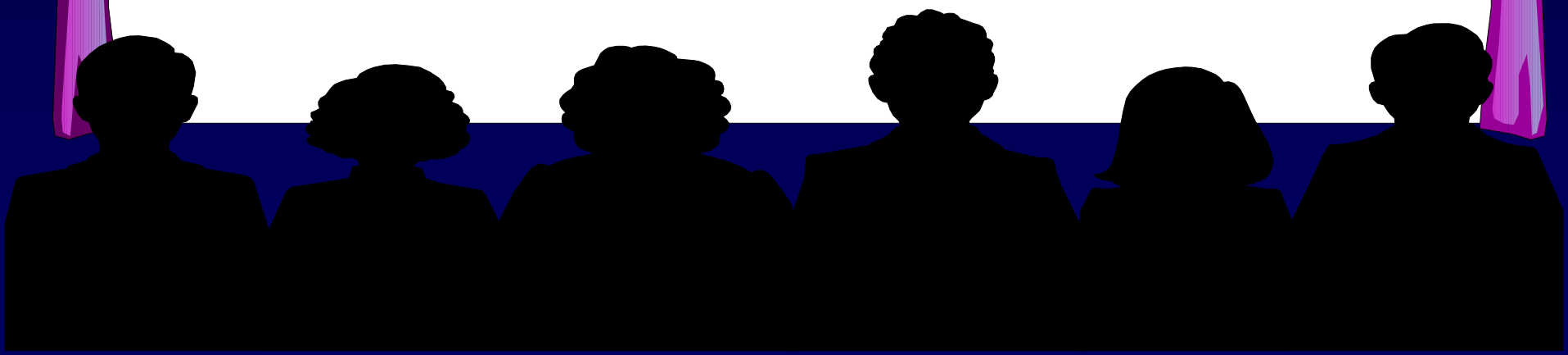
Where VOC Emissions Occur? MOBILE6.2

- Start Exhaust (26%)
  - Vehicle trip starts/ends (roadway) & parking lots
- Running Exhaust and Running Loss (47%)
  - Roadway
- Hot Soak and Diurnal Soak (10%)
  - vehicle trip starts/ends, & parking lots
- Refueling (8%)
  - Associated with gas stations
- Crankcase and Resting Loss
  - Continuous (emitted at all times)
  - Not assigned to roadways in MOBILE6

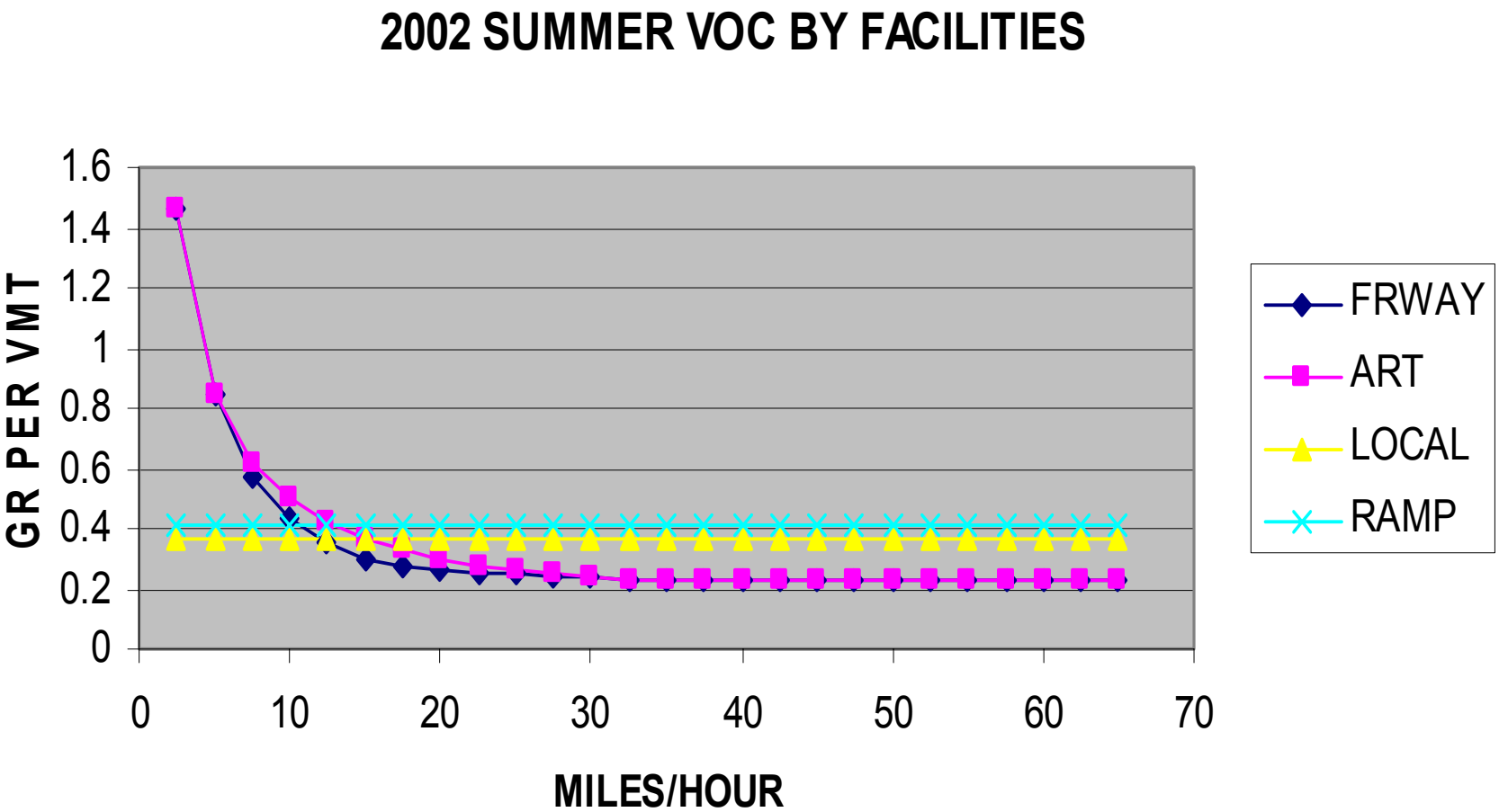
MOVES Modeling Approaches Allocating HC Emissions

- SHO
  - Source type by age & hour
- SHP
  - All source hours minus SHO
  - Vehicles per zone & hours
  - Parking spaces & hours
- Allocating HC & Air Toxics
  - Links, zones, counties, and facilities
  - Micro-scale analysis
  - Giant step forward in emissions modeling

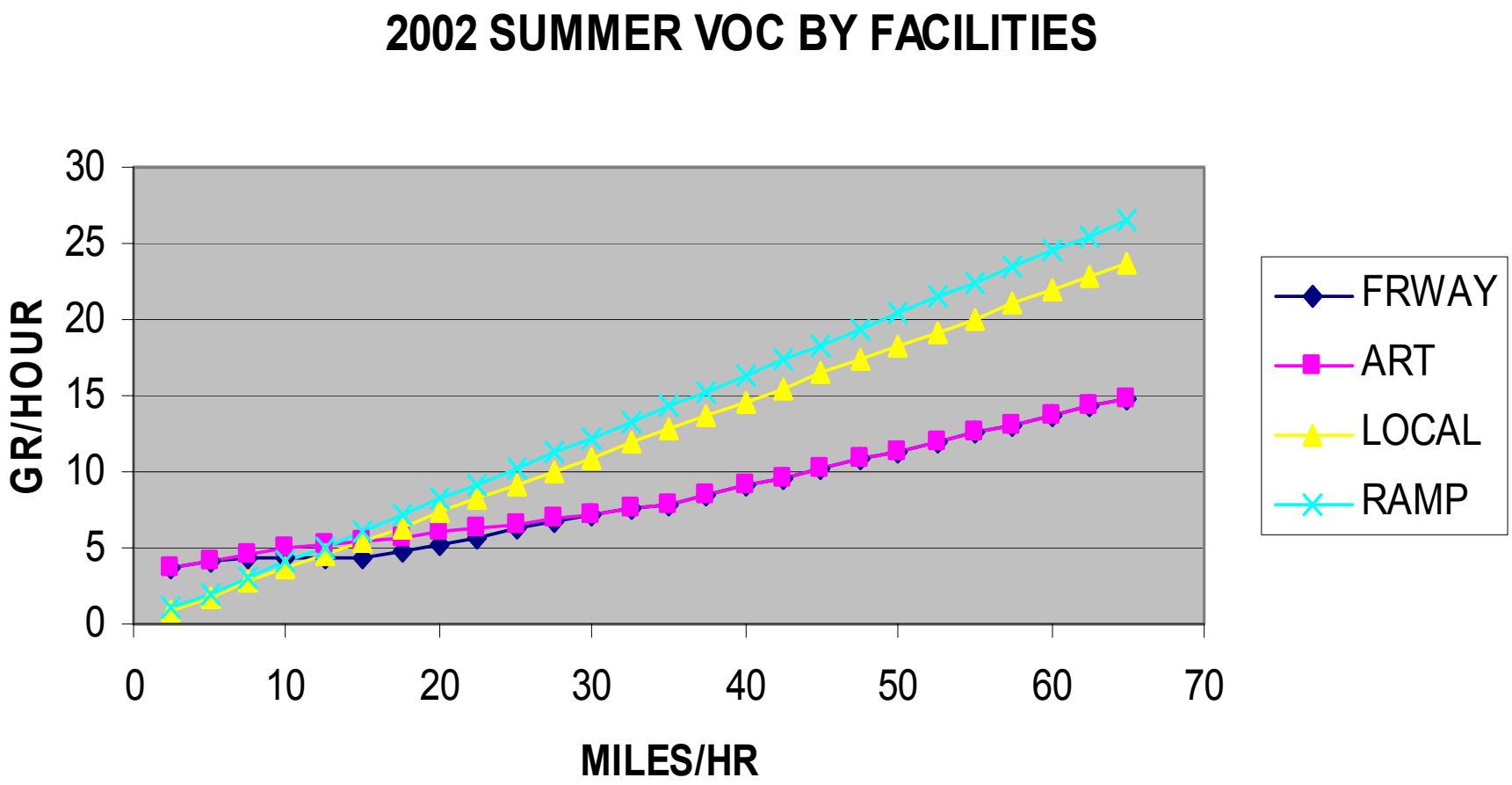
3. VMT vs. VHT (SHO) Based Model



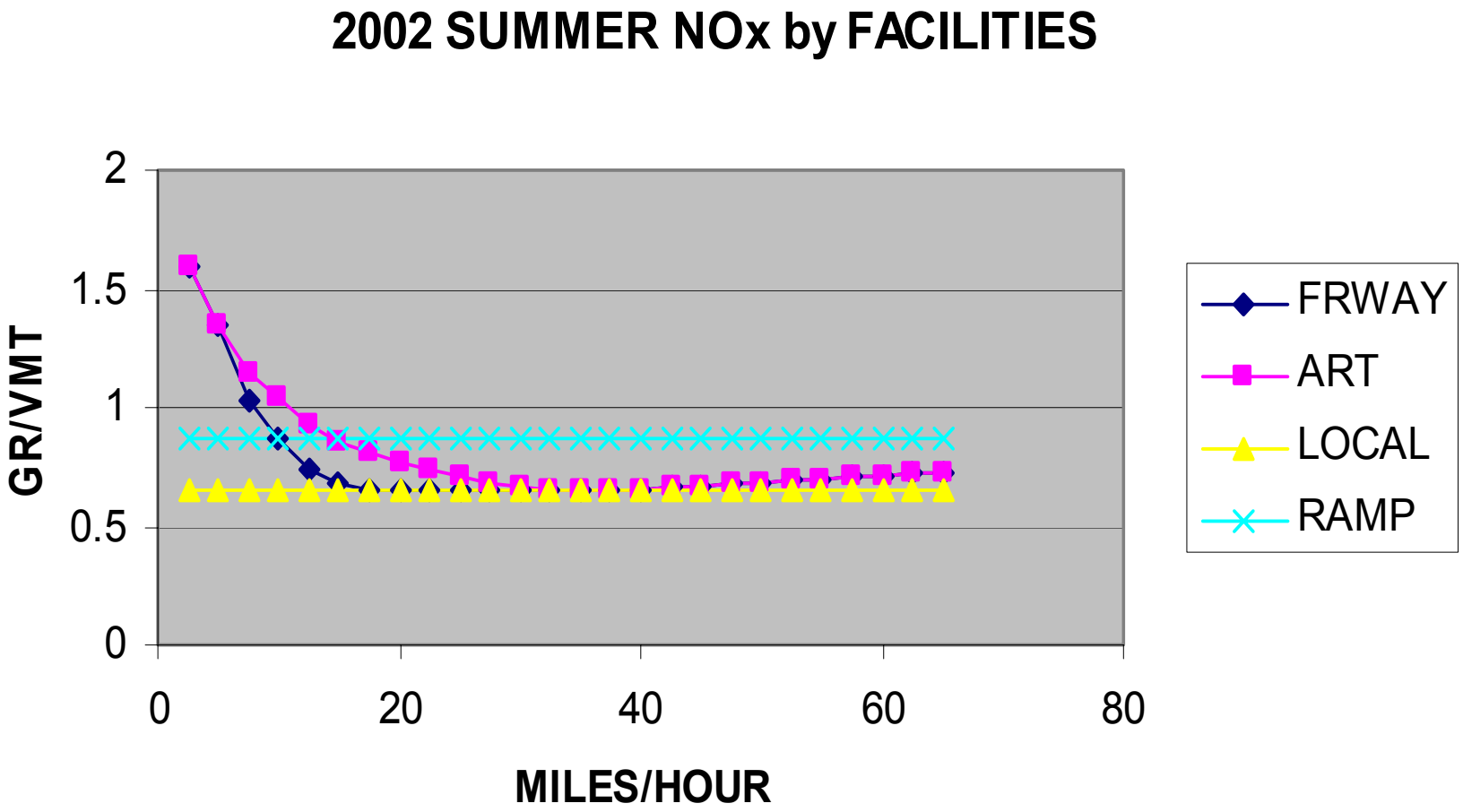
HC Emission Factors
Grams per VMT



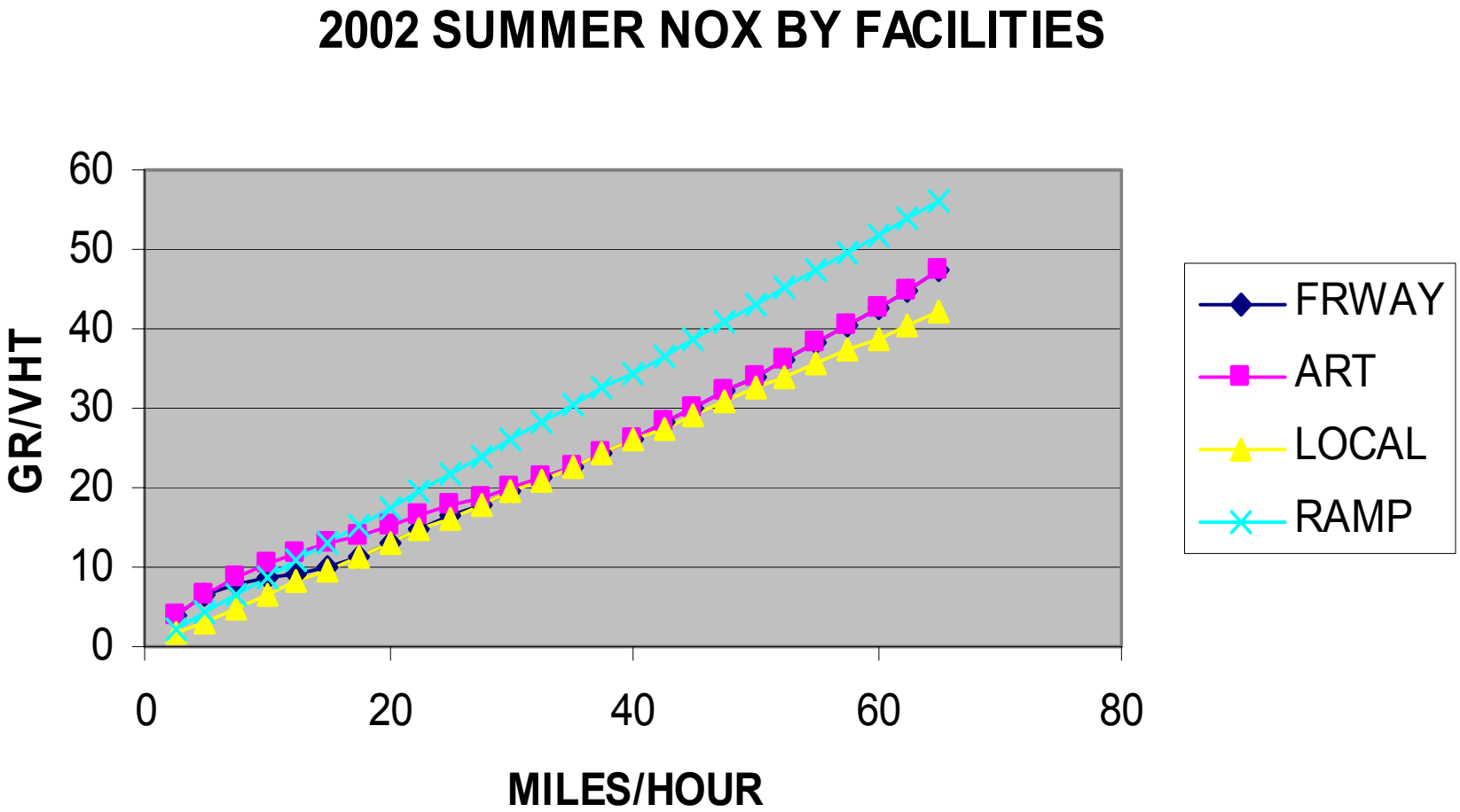
HC Emission Factors
Grams per VHT



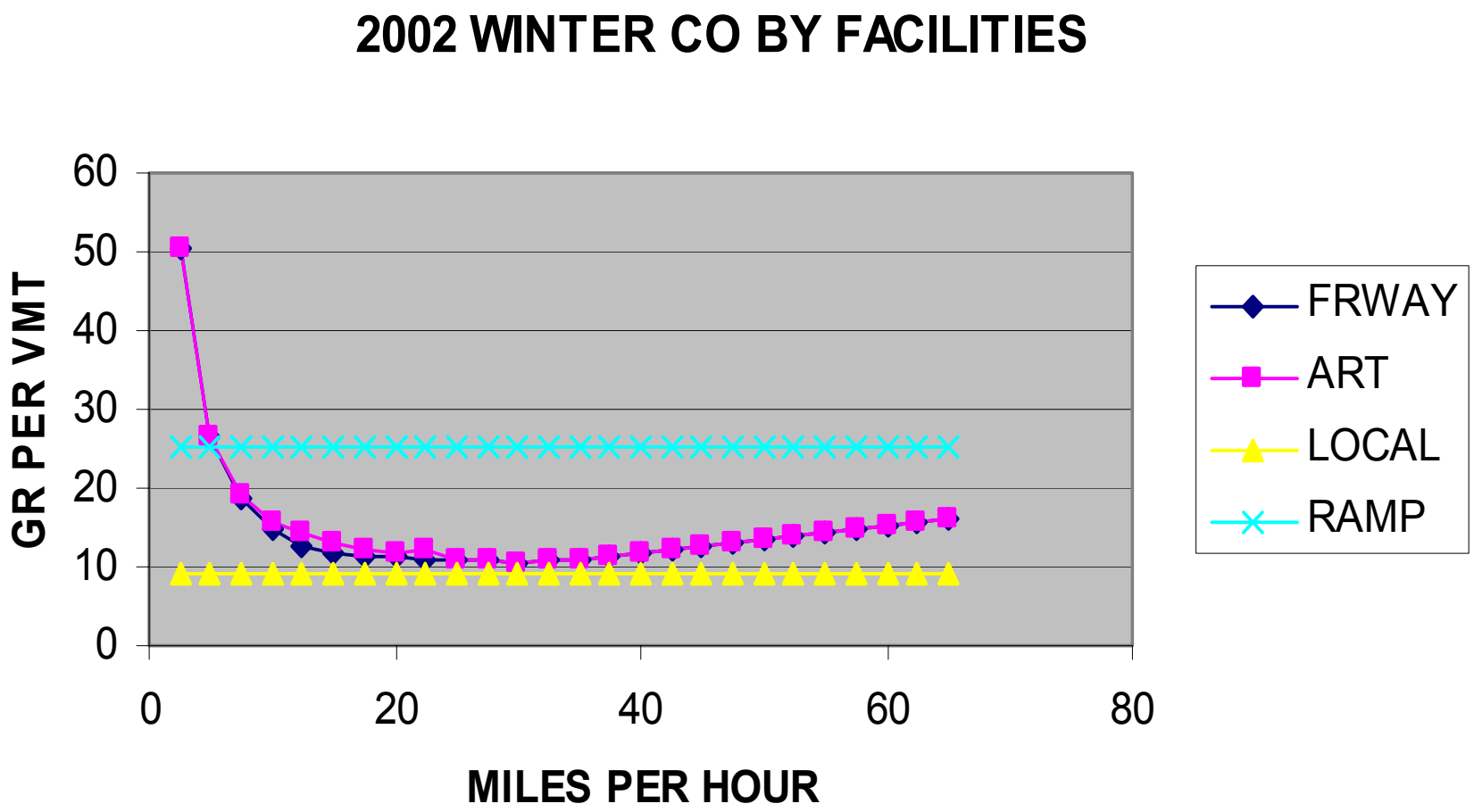
NOx Emission Factors Grams per VMT



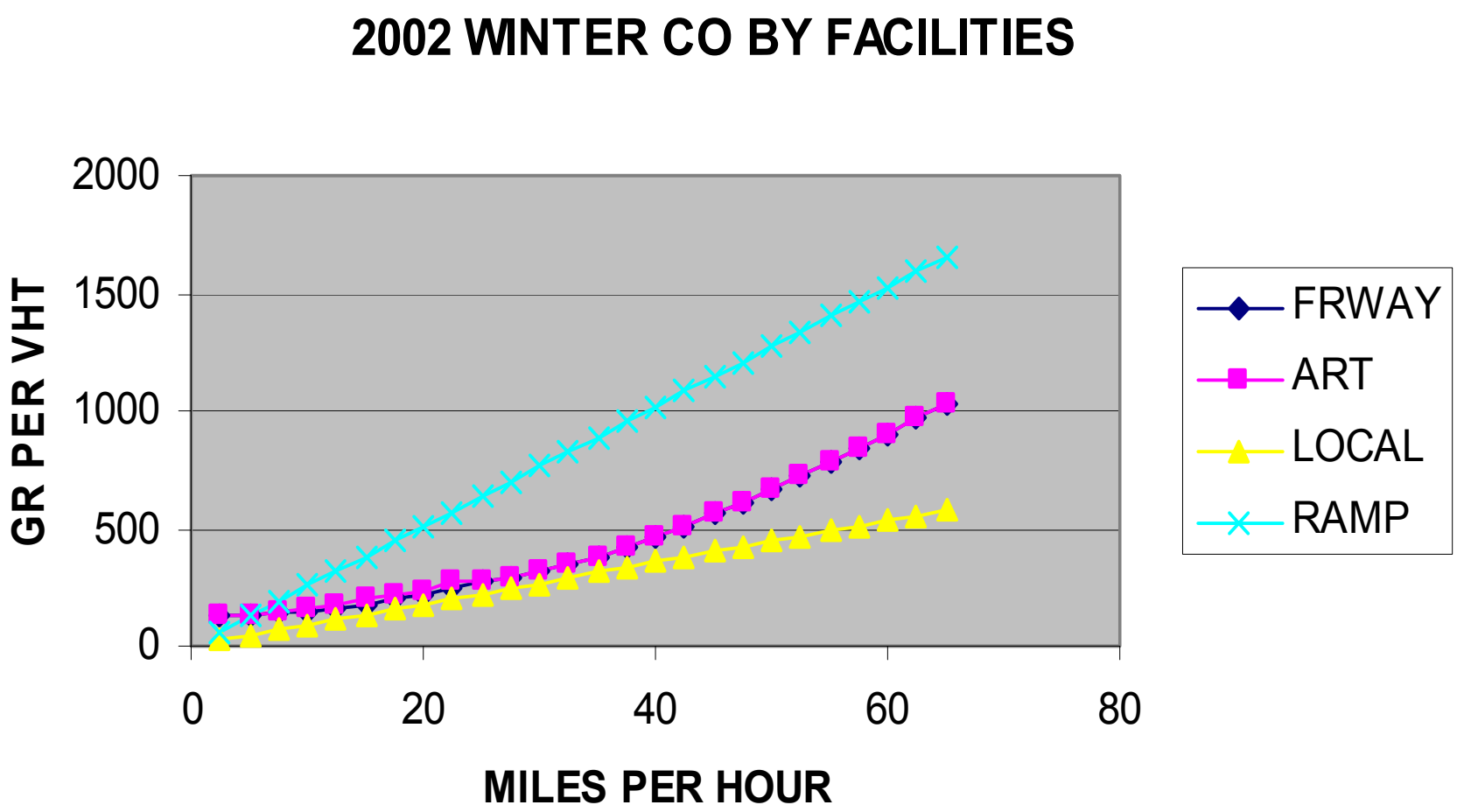
NOx Emission Factors Grams per VHT



CO Emission Factors
Grams per VMT



CO Emission Factors
Grams per VHT



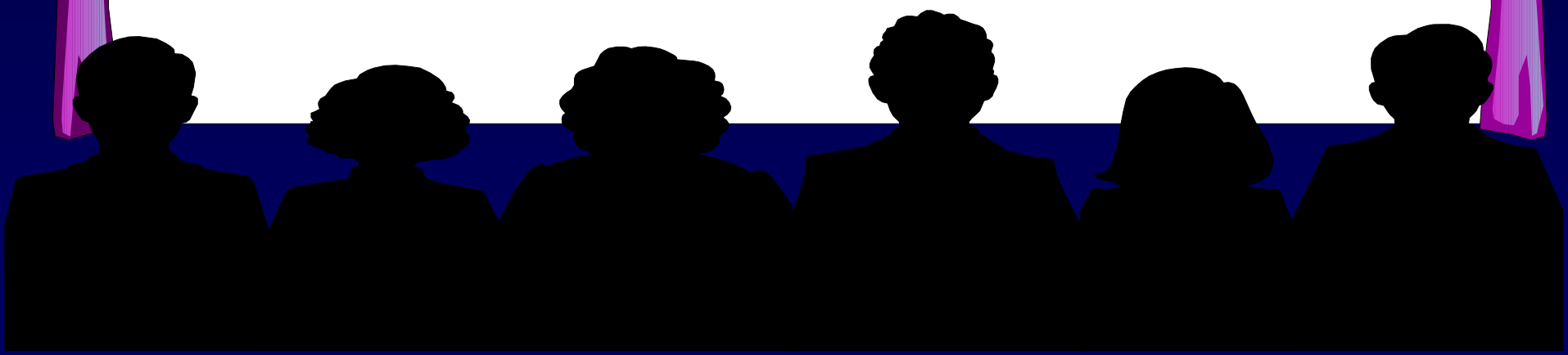
Emission Factors vs. VSP and Grams per SHO (VHT)

- Model default VSP Distributions
  - Facility based fixed drive cycles
  - Similar as MOBILE6 curves
- Start Emissions
  - Allocating emissions to traffic zones
  - Allocating emissions to geo-grid system
- Micro-scale project level AQ analyses
  - Models needed to generate VSP information

Converting VMT to SHO (VHT)

- TDF
  - Average speed for given link & volume
  - Peak, off-peak or 4-5 time periods
- HCM
  - Average speeds for given facility & volume
  - 15 minutes interval
- Traffic models
  - Calibrated BPR curves (hourly)
  - NETSIM, CORSIM (sec. by sec., accel., & decel.)
- MOVES
  - Facility based speed (not by source types)
  - 5 mph increments (hourly?)

4. Vehicle Fleet



Vehicle Types

- TDF Models (4-step)
  - Person Trips
  - Mode Split Step
    - Walk, Bike, Auto, Carpool, Vanpool
    - Transit (bus, rail)
- Commercial trucks
  - Added to TDF models (common practice)
  - Separate freight models (very much needed)
- HPMS
  - Traffic volume
  - Road way design
- Hot spot analysis
  - Vehicle age varies by HH income & sub-area

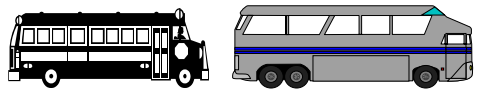
HPMS Vehicle Classification

(1) Motorcycles

(2) Passenger Cars (w/ 1 or 2 axle trailers)

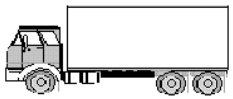
(3) Two Axle, 4 Tire Single Units.
Pickup or Van w/ 1 or 2 axle trailers

(4) Buses

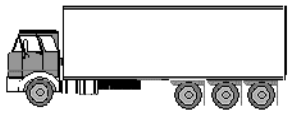


(5) 2D – Two Axle, Six Tire Single Unit
Includes Handicapped Equipped & Mini School Buses.

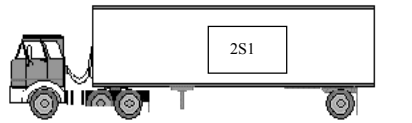
(6) 3 Axles Single Unit

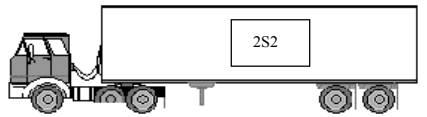


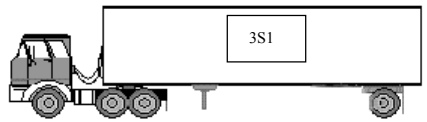
(7) 4, or more, Axles Single Unit



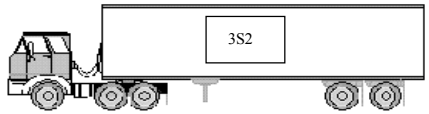
(8) 3-4 Axles, Single Trailer

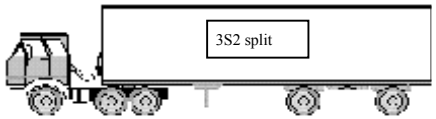




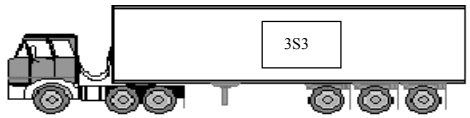


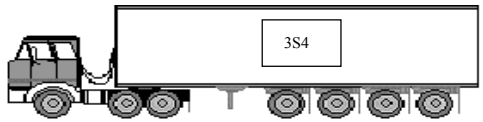
(9) 5 Axles Single Trailer





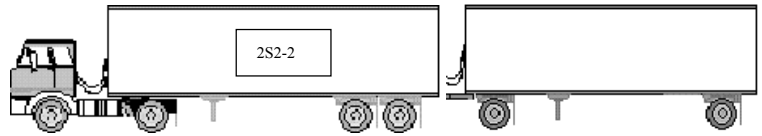
(10) 6, or more, Axles Single Trailer

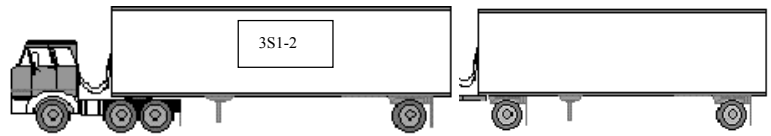




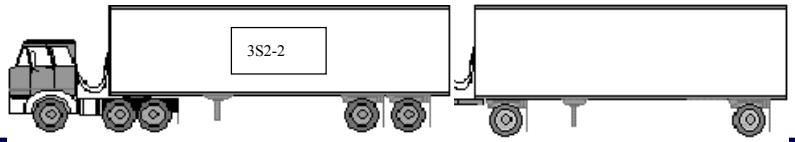
(11) 5, or less, Axles Multi-Trailers

(12) 6 Axles Multi-Trailers





(13) 7, or More, Axles Multi-Trailers



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Vehicle Classes
MOVES vs. MOBILE

- MOVES
  - 13 vehicle types
  - Close ties to HPMS vehicle types
  - Handles mapping internally
    - No separation by fuel types
    - Optional local mapping (?)
- MOBILE6.2
  - 28 Vehicle Types
    - Fuel & gross vehicle weight
  - Requires external mapping

Vehicle Types
HPMS vs. MOVES

HPMS Vehicle Type	MOVES2004 SourceType	MOVES2006 SourceType ?
Motorcycle	Motorcycle	Motorcycles
Passenger Car	Passenger Car	Passenger Cars
Other 4-tire, 2 axle	Passenger Truck Light Commercial Truck	Light Trucks
Bus	Intercity Bus Transit Bus School Bus	Buses
Single Unit Truck	Refuse Trucks Short-haul Single Unit Long-haul Single Unit Motorhomes	Single Unit Trucks
Combination Truck	Short-haul Combination Long-haul Combination	Combination Trucks

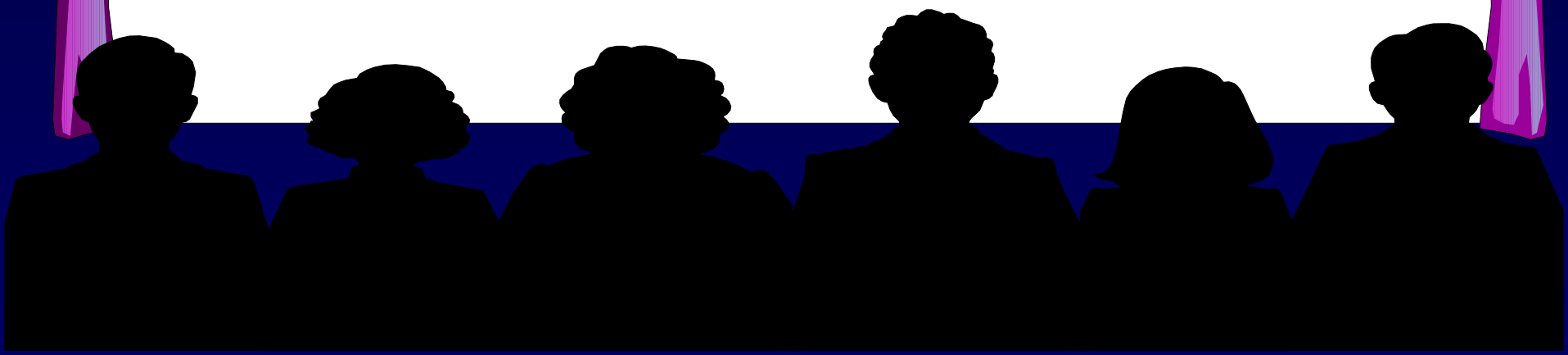
Vehicle Types by Age

- **Local vehicle registration data**
  - Commercial trucks
  - E-E & E-I VMT
- **1 – 25+ vehicle age bins**
  - New technology vehicles
  - Limits the modeling horizon years
- **Hot spot analysis**
  - Vehicle age varies by HH income & sub-area

Transportation Projects Impacted by Vehicle Types & Fuel

- **Local bus projects**
  - Transit/school bus renewal
  - Alternative fuel buses
- **Gasoline vs. diesel**
  - Internal mapping by county level?
  - Default mapping applies to all local areas?
- **Policies based on fuel**
  - Mix of alcohol, bio-diesel etc.
- **Hot spot analysis**
  - Short vs. long haul trucks
  - Gasoline vs. diesel cars/pickups

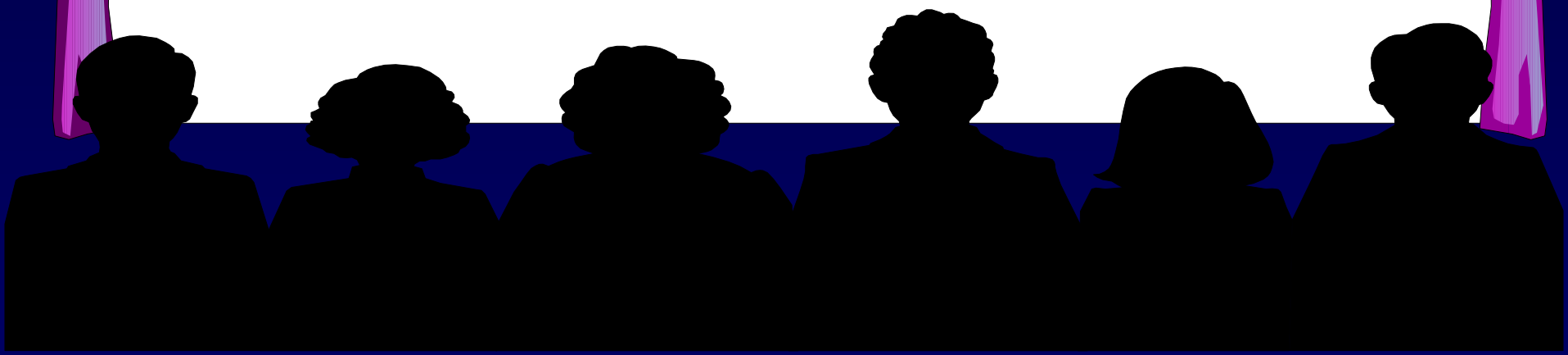
5. Government Programs



I/M in MOVES

- Single set of "With I/M" emission rates
- I/M adjustment fraction will account for program effectiveness
- Program options: vehicle & MY coverage, inspection frequency (annual, biennial, etc.)

6. Major Upgrades



MOVE2006
Major Information Updates

- Fleet & Activity Data
  - Sales & VMT growth
  - High speed drive cycles
  - Updated 1999 estimates
  - New in-use data
- Activity components related to start & evaporative emissions
  - Starts per vehicle by hour
  - Soak time distribution

MOVES2006
Changes from MOVES2004

- Road Types 13 → 5
  - Off-network, Rural Limited Access, Urban Limited Access, Rural Other, Urban Other
- Days 7 → 1
  - Weekday/Weekend distinctions (option)
- Additional road types and days can be modeled if user provides the information

Creating User Inputs

- Default data can be replaced by user-supplied data via MySQL
  - Example: user wishes to replace national VMT with local VMT for 1999 base year

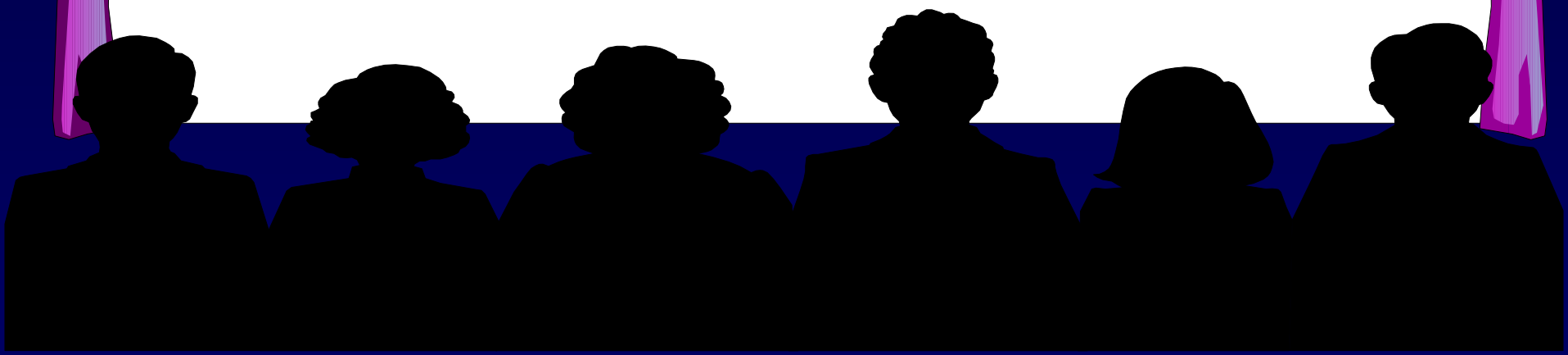
Local Area Inputs

- Minimum: Redefine modeling domain
  - Replace national VMT with local VMT
  - Replace activity allocation factors
- Additional options:
  - Age distributions
  - Temporal allocation
  - Average speed distributions
  - Driving patterns from in-use survey
  - Etc.

Output

- Post-processing scripts
- Exporting MOVES output to EXCEL
- MySQL to summarize output

7. Anticipated Major Impacts



Anticipated Major Impacts

- **Vehicle classes and VMT fractions**
- **I/M programs**
- **VSP approaches vs. speed**
  - Opens the door for micro-scale modeling
  - Variable drive cycles
  - Hot spot, NEPA projects etc.
- **Start and evaporative emissions**
  - Emissions inventory
  - Project level
- **Redefining the evaporative emission categories**
  - Consistency issues